



AIR-CONDITIONING
& REFRIGERATION
INSTITUTE

Representing Manufacturers
of Heating, Ventilating,
Air-Conditioning and
Refrigeration Products

May 30, 2003

Mr. Bill Pennington
Project Manager
Energy Efficiency and Demand Analysis Division
California Energy Commission
1516 Ninth Street, MS-28
Sacramento, CA 95814

RE: ARI Comments on CEC Title 24 Proposed Building Standards (draft dated February 25, 2003)

Dear Mr. Pennington:

The Air-Conditioning and Refrigeration Institute (ARI) would like to submit these comments in response to the California Energy Commission's (CEC) February 2003 draft proposed Title 24 Building Energy Efficiency Standards.

ARI is a national trade association representing the manufacturers of over 90% of U.S. produced air conditioning and commercial refrigeration equipment. ARI represents a domestic industry of over 211 air conditioning and refrigeration companies, employing approximately 150,000 men and women in the United States (U.S.). The total value of member shipments by these companies is over \$30 billion annually. These comments are submitted on behalf of our members.

We have reviewed the draft proposed standards and have the following comments:

Tables 112 D, I, J and K

The Integrated Part Load Values (IPLV) proposed by the CEC in Tables 112 D, I, J and K are outdated as they are based on an older version of ARI Standards 550 and 590. In 1998, ARI revised the two standards and combined them into one document, namely ARI standard 550/590-98. Two major changes were made to the standards which affect how chillers are rated and tested. The two major changes were with respect to the IPLV and the fouling factor adjustment used for evaporators in closed loop water systems. The IPLV rating conditions and part load weightings were changed to more closely reflect actual operating experience found in the field for a single chiller. The evaporator fouling factor was changed from 0.00025 to 0.0001 based on research work sponsored by The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE). Subsequently, in 2000, the ASHRAE 90.1 committee revised the IPLV

values and published addendum j to ASHRAE 90.1-1999 (a copy of the addendum is attached below). The CEC should adopt these values in Title 24.

Section 144 (i)

The CEC should delete Section 144(i) in its entirety for several reasons. The requirements in Section 144 (i) essentially eliminate air-cooled chillers above 100 tons from being sold in California. This is a restraint of trade, which we believe was not what the Commission intended to do when it drafted the section. ARI strongly believes that chiller selection should be based on a life cycle cost (LCC) analysis and not dictated by regulations. In addition, there are several reasons why the use of air-cooled chillers should not be restricted including the following:

- There are geographic areas in California today where the supply and quality of water is limited, to say nothing about the future availability of water.
- Not only the availability of water but also the cost of water for tower makeup can be significant and must be considered in the overall life cycle analysis of the building.
- Chemical treatment of the cooling tower water is another added cost for water-cooled systems and must be considered in the overall life cycle analysis of the building.
- Water-cooled systems require a higher skill level of operating personnel that may not be available on a particular job site.
- Putting this restriction on air-cooled chillers will inevitably move the market towards unitary air-cooled packaged systems and not water-cooled chillers.
- The efficiency of air-cooled chillers has improved substantially, particularly at part load due to the use of multiple compressors and fans. High efficiency chillers are now available and are being proposed for California Title 24 in 2005. The proposed levels increase efficiency by 7.1% full load and 42.5% IPLV compared to current levels.
- The analysis conducted to justify limiting air-cooled chillers was based on the current Title 24 efficiencies. This is an unreasonable analysis in light of the proposed new levels.
- Concern for Legionnaires disease, often associated with water-cooled systems, can be a factor in the decision to specify air-cooled chillers.
- It is very difficult to compare different chiller technologies on an equal basis as the applications can vary significantly and one system may not be the best choice for all applications. The chiller(s) selection should be based on a building energy and LCC analyses and not mandated by codes or standards.

Section 152 (b) E

ARI believes that ducts should be properly sealed to minimize energy losses. However, we feel that it is inappropriate to require duct sealing at the time the air conditioning system or the coils are replaced. As proposed, Section 152 (b) E requires that consumers spend approximately \$1,000 to properly seal leaky ducts in addition to the cost of replacing the air conditioning system. ARI believes that

the additional cost to comply with this requirement will very likely push consumers to keep older less efficient products much longer than needed resulting in more energy losses.

Instead of this requirement, ARI suggests that the CEC mandate an energy audit of the residential building at the time the property is sold. In the event that the audit reveals that the ducts are leaky, the seller of the property will be required to seal the ducts in accordance with the CEC procedures. Doing so will not discourage the replacement of air conditioners and at the same time will make sure that ducts are properly sealed.

We appreciate the opportunity to submit these comments. If you have any questions regarding this submission, please feel free to contact me.

Sincerely,

A handwritten signature in black ink, appearing to read 'K Amrane', with a stylized, cursive script.

Karim Amrane
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Enclosures: As stated

**BSR/ASHRAE/IESNA Addendum *j*
to ASHRAE/IESNA Standard 90.1-1999**

This supplement will be submitted to the American National Standards Institute Board of Standards Review (BSR) for approval.

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

FIRST PUBLIC REVIEW
June 2000

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This draft has been recommended for public review by the responsible project committee. Public review of this proposed addendum has been authorized by a subcommittee of the Standards Committee. Until final approval by the ASHRAE Board of Directors, this draft addendum is subject to modification and Standard 90.1-1999 remains in effect. Instructions and a form for commenting are provided with this draft. Although reproduction of drafts during the public review period is encouraged to promote additional comment, permission must be obtained to reproduce all or any part of this document from the ASHRAE Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. Phone: 404-636-8400, Ext. 502. Fax: 404-321-5478. E-mail: cramspeck@ashrae.org.

The parent standard, not including this proposed change, is under continuous maintenance. The change submittal form, instructions and deadlines may be obtained in electronic form from ASHRAE's Internet Home Page, <http://www.ashrae.org>, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

**AMERICAN SOCIETY OF HEATING,
REFRIGERATING AND
AIR-CONDITIONING ENGINEERS, INC.**
1791 Tullie Circle, NE · Atlanta GA 30329

NOTICE

COMMENTS ON DRAFT STANDARDS (Revised December 4, 1998)

1. INSTRUCTIONS FOR FILING COMMENTS:

- a) Comments on this standard:
 - 1) must comply with these and other instructions provided in the Form for Commenting,
 - 2) must be received by **August 7, 2000**.
 - 3) must be substantiated,
 - 4) must be signed and dated,
 - 5) may be submitted electronically on the *Form for Commenting* attached to the standard. Submittal in paper form is acceptable, but electronic submittal is preferred.
 - 6) must be sent to ASHRAE Manager of Standards.
- b) Comment forms may be submitted electronically either as files (MS Word 7 preferred) attached to e-mail (UUENCODE preferred), files uploaded to an ftp site, or on 3.5" floppy disk. **Commenters' signatures are required on all electronic files sent on disk, uploaded to the ftp site, or sent via e-mail to convey non-exclusive copyright.** For signature submittal, choose one of the following methods:
 - (1) sign the comment forms electronically, or
 - (2) send a copy of the comment form via mail or fax with the commenter's signature and indicate whether the original comments are on disk, uploaded to the ftp site, or sent via e-mail.

NOTE: If the method (2) is used, then the box beneath the signature line on the *Form for Commenting* must be checked.

Submit public review comments to:

Manager of Standards

ASHRAE

1791 Tullie Circle, NE

Atlanta, GA 30329-2305

E-mail: public.review.comment@ashrae.org

Ftp server address: <ftp.ashrae.org>, logon to anonymous ftp in directory: *public.review.comment*.

(Alternatively, mail paper versions to ASHRAE address or Fax: 404-321-5478.)

- c) In your comments, please specify whether you approve or disapprove of the proposed document. If you provide technical comments with your approval, indicate whether approval is contingent upon considering them for inclusion (1) in the current proposal or (2) in future revisions of the current proposal. If you disapprove, give your reasons.
- d) Supplemental background documents to support your comments may be included. Highlighting pens should not be used since highlights will not reproduce. Please do not return marked-up copies of the draft.
- e) In the event that the cover page denotes an Independent Substantive Change (ISC), additions to the text will be shown by underlining and deletions by strikethrough, unless otherwise indicated. Only these changes will open for review and comment at this time. Additional material will be provided for context only and not open for comment except as it relates to the proposed substantive changes. The additional material may or may not have previous commentor's non-substantive or editorial changes made to it at this time.

2. INFORMATION ON REVIEW AND DISPOSITION OF COMMENTS:

All comments received by ASHRAE will be acknowledged. Comments submitted on the *Form for Commenting* provided and complying with the instructions provided on the Form and in 1(a)-(b) above will be forwarded to the Project Committee for consideration. The Project Committee will inform commenters of the proposed disposition of their comments unless the Manager of Standards informs commenters that there will be another public review.

3. SUPPLEMENTAL INSTRUCTIONS TO COMMENTERS

Commenters must submit comments to ASHRAE Headquarters on the form provided. Submittal in electronic form is preferred. Submittal in paper form is acceptable. A paper version of the comment form is included in the public review draft standard.

Following are supplementary instructions for some of the numbered sections in the Form for Commenting:

- a) Provide all of commenter's contact information, including E-mail or Internet address if available.
- b) Sign and date the non-exclusive copyright release. (See 1b.)
- c) Identify the specific section that is the subject of the comment. Use a separate form for each comment.
- d) Provide specific wording changes or action that would resolve commenter's concerns.
- e) Provide a brief substantiation statement that presents the rationale, and supporting documentation as well as any technical data and back up. Provide an abstract of lengthy substantiations. If supplementary documents are provided, electronic files in wordprocessed (MS Word 7 preferred) or scanned form are preferred. Indicate whether attachments have been provided.

(This foreword is provided for information only and is not part of the draft addendum.)

FOREWORD

Draft Addendum 90.1j – 1st Public Review Draft. ASHRAE Standard 90.1 currently references ARI Standards 550-92 and 590-92 for chillers. ARI recently revised these standards, and combined them into one volume, namely ARI-550/590-98. In the process of combining the standards, they were updated to incorporate certain revisions as described in detail in a **white paper** available from ARI (<http://www.ari.org/std/individual/550.590-98wp.pdf>). ARI member companies, consisting of the major chiller manufacturers, did extensive correlation testing between the old and new standards to determine the effects of the revisions. To correct a discrepancy between Tables 6.2.1 C and H, Table 6.2.1 H values were corrected with the COP at standard rating condition equal to the COP in Table 6.2.1 C. Other values were adjusted accordingly. The 90.1 Mechanical Subcommittee reviewed the white paper and correlation tests and agreed to accept the recommended changes, which are reflected in the proposed addenda.

Addendum 90.1j

Proposed Addenda to Section 6.2.1 & Corresponding Tables 6.2.1C, H, I & J of 90.1-1989R for Chiller Efficiency Requirements

1. Change wording of 6.2.1 as shown below:

Exception to 6.2.1: Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard ~~550~~ 550/590 test conditions (and thus cannot be tested to meet the requirements of Table 6.2.1C) of 44°F leaving chilled water temperature and 85°F entering condenser water temperature shall have a minimum full load COP ~~and IPLV rating~~ as shown in Tables 6.2.1 H, I and J and a minimum NPLV rating as shown in Tables 6.2.1 K, L, and M beginning on 10-29-2001 (prior to 10-29-2001 there are no ~~current~~ minimum efficiency requirements for chillers that are not designed to operate at standard ARI test conditions). The table values are only applicable over the following full load design ranges:

Leaving Chiller Water Temp.: 40 to 48°F

Entering Condenser Water Temp.: 75 to 85°F

Condensing Water Temp.Rise: 5 to 15°F

Chillers designed to operate outside of these ranges are not covered by this standard.

Non-Standard Part Load Value (NPLV) is defined as a single number part-load efficiency figure of merit for chillers referenced to conditions other than IPLV conditions.

2. Change chiller efficiency tables 6.2.1C, I, & J as attached, replace table 6.2.1 H with the attached new table 6.2.1 H and add new tables 6.2.1 K, L, & M. The IP tables are attached.

The corresponding SI tables require the same changes.

3. Change Section 12, Normative References, by replacing 550-92 and 590-92 with ARI 550/590-98, Water Chilling Packages Using the Vapor Compression Cycle.

[See also attached tables 6.2.1 C, H, I, J, K, L & M]

Table 6.2.1C (I-P Units)
Water Chilling Packages, Minimum Efficiency Requirements

Equipment Type	Size Category	Minimum Efficiency ^b	Efficiency as of 10/29/2001 ^b	Test Procedure ^a
Air Cooled, With Condenser, Electrically Operated	<150 Tons	2.70 COP <u>3.00</u> 2.80 IPLV	2.80 COP <u>3.05</u> 2.80 IPLV	ARI 550 or ARI 590 as appropriate <u>ARI 550/590</u>
	≥150 Tons	2.50 COP <u>2.75</u> 2.50 IPLV		
Air Cooled Without Condenser, Electrically Operated	All Capacities	3.10 COP <u>3.55</u> 3.20 IPLV	3.10 COP <u>3.45</u> 3.10 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities	3.80 COP <u>4.25</u> 3.90 IPLV	4.20 COP <u>5.05</u> 4.65 IPLV	ARI 590 <u>ARI 550/590</u>
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	<150 Tons	3.80 COP <u>4.45</u> 3.90 IPLV	4.45 COP <u>5.20</u> 4.50 IPLV	ARI 550 or ARI 590 as appropriate <u>ARI 550/590</u>
	≥150 Tons and <300 Tons	4.20 COP <u>5.05</u> 4.50 IPLV	4.90 COP <u>5.60</u> 4.95 IPLV	
	≥300 Tons	5.20 COP <u>5.80</u> 5.30 IPLV	5.50 COP <u>6.15</u> 5.60 IPLV	
Water Cooled, Electrically Operated, Centrifugal	<150 Tons	3.80 COP <u>4.10</u> 3.90 IPLV	5.00 COP <u>5.25</u> 5.00 IPLV	ARI 550 <u>ARI 550/590</u>
	≥150 Tons and <300 Tons	4.20 COP <u>4.80</u> 4.50 IPLV	5.55 COP <u>5.90</u> 5.55 IPLV	
	≥300 Tons	5.20 COP <u>5.60</u> 5.30 IPLV	6.10 COP <u>6.40</u> 6.10 IPLV	
Air Cooled Absorption Single Effect	All Capacities	0.48 COP	0.60 COP	ARI 560
Water Cooled Absorption Single Effect	All Capacities	0.60 COP	0.70 COP	
Absorption Double Effect Indirect-Fired	All Capacities	0.95 COP 1.00 IPLV	1.00 COP 1.05 IPLV	
Absorption Double Effect Direct-Fired	All Capacities	0.95 COP 1.00 IPLV	1.00 COP 1.00 IPLV	

^a Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

^b The chiller equipment requirements do not apply for chillers used in low temperature applications where the design leaving fluid temperature is less than or equal to 40°F.

Table 6.2.1 H (I-P Units)
COPs for Centrifugal Chillers < 150 Tons

COP_{std} = 5.0

Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT ^a	Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP					
46	75	29	5.58	5.83	6.03	6.32	6.54	6.70
45	75	30	5.50	5.74	5.92	6.19	6.38	6.53
44	75	31	5.42	5.65	5.82	6.07	6.24	6.37
43	75	32	5.35	5.57	5.72	5.95	6.11	6.23
42	75	33	5.27	5.49	5.64	5.85	6.00	6.11
41	75	34	5.19	5.41	5.56	5.75	5.89	5.99
46	80	34	5.19	5.41	5.56	5.75	5.89	5.99
40	75	35	5.11	5.33	5.48	5.67	5.79	5.88
45	80	35	5.11	5.33	5.48	5.67	5.79	5.88
44	80	36	5.03	5.26	5.40	5.58	5.70	5.79
43	80	37	4.94	5.18	5.32	5.50	5.62	5.70
42	80	38	4.84	5.10	5.25	5.43	5.53	5.61
41	80	39	4.73	5.01	5.17	5.35	5.46	5.53
46	85	39	4.73	5.01	5.17	5.35	5.46	5.53
40	80	40	4.62	4.92	5.09	5.27	5.38	5.45
45	85	40	4.62	4.92	5.09	5.27	5.38	5.45
44	85	41	4.49	4.82	5.00	5.20	5.30	5.38
43	85	42	4.35	4.71	4.91	5.12	5.23	5.30
42	85	43	4.19	4.59	4.81	5.03	5.15	5.22
41	85	44	4.02	4.46	4.70	4.94	5.06	5.14
40	85	45	3.84	4.32	4.58	4.84	4.98	5.06

Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68
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^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1I (I-P Units)

COPs and IPLVs for Non-Standard Centrifugal Chillers > 150 Tons ≤ 300 Tons

COP_{std} = 5.55

Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT ^a	Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP and IPLV					
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.90	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59

Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68
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^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1J (I-P Units)

COPs and IPLVs for Non-Standard Centrifugal Chillers > 300 Tons

COP_{std} = 6.1

Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT ^a	Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP and IPLV					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17

Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68
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^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1K
IPLV/NPLV for Centrifugal Chillers < 150 Tons

IPLV _{std} = 5.25			Condenser Flow Rate						
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton	
Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT ^a	Required IPLV/NPLV						
46	75	29	5.84	6.10	6.30	6.61	6.84	7.00	
45	75	30	5.75	6.00	6.19	6.47	6.68	6.83	
44	75	31	5.67	5.91	6.08	6.34	6.53	6.67	
43	75	32	5.59	5.82	5.99	6.23	6.39	6.52	
42	75	33	5.51	5.74	5.90	6.12	6.27	6.39	
41	75	34	5.43	5.66	5.81	6.02	6.16	6.26	
46	80	34	5.43	5.66	5.81	6.02	6.16	6.26	
40	75	35	5.35	5.58	5.73	5.93	6.06	6.15	
45	80	35	5.35	5.58	5.73	5.93	6.06	6.15	
44	80	36	5.26	5.50	5.65	5.84	5.96	6.05	
43	80	37	5.16	5.42	5.57	5.76	5.87	5.96	
42	80	38	5.06	5.33	5.49	5.67	5.79	5.87	
41	80	39	4.95	5.24	5.41	5.60	5.71	5.78	
46	85	39	4.95	5.24	5.41	5.60	5.71	5.78	
40	80	40	4.83	5.14	5.32	5.52	5.63	5.70	
45	85	40	4.83	5.14	5.32	5.52	5.63	5.70	
44	85	41	4.69	5.04	5.25^c	5.43	5.55	5.62	
43	85	42	4.55	4.93	5.13	5.35	5.47	5.54	
42	85	43	4.38	4.80	5.03	5.26	5.38	5.46	
41	85	44	4.21	4.67	4.91	5.17	5.30	5.38	
40	85	45	4.01	4.52	4.79	5.06	5.20	5.29	
			Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68

^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

^c All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1L

IPLV/NPLV for Centrifugal Chillers > 150 Tons ≤ 300 Tons

IPLV _{std} = 5.9			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT ^a	Required IPLV/NPLV					
46	75	29	6.58	6.87	7.11	7.46	7.71	7.90
45	75	30	6.49	6.76	6.98	7.30	7.53	7.70
44	75	31	6.40	6.66	6.86	7.15	7.36	7.52
43	75	32	6.31	6.56	6.75	7.02	7.21	7.35
42	75	33	6.22	6.47	6.65	6.90	7.07	7.20
41	75	34	6.13	6.38	6.55	6.79	6.95	7.06
46	80	34	6.13	6.38	6.55	6.79	6.95	7.06
40	75	35	6.03	6.29	6.46	6.68	6.83	6.94
45	80	35	6.03	6.29	6.46	6.68	6.83	6.94
44	80	36	5.93	6.20	6.37	6.58	6.72	6.82
43	80	37	5.82	6.11	6.28	6.49	6.62	6.72
42	80	38	5.71	6.01	6.19	6.40	6.53	6.62
41	80	39	5.58	5.91	6.10	6.31	6.44	6.52
46	85	39	5.58	5.91	6.10	6.31	6.44	6.52
40	80	40	5.44	5.80	6.00	6.22	6.35	6.43
45	85	40	5.44	5.80	6.00	6.22	6.35	6.43
44	85	41	5.29	5.68	5.90^c	6.13	6.26	6.34
43	85	42	5.13	5.55	5.79	6.03	6.16	6.25
42	85	43	4.94	5.41	5.67	5.93	6.07	6.16
41	85	44	4.74	5.26	5.54	5.82	5.97	6.07
40	85	45	4.52	5.09	5.40	5.71	5.87	5.97
Cond DT ^b			14.04	11.23	9.36	7.02	5.62	4.68

^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

^c All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1M
IPLV/NPLV for Centrifugal Chillers > 300 Tons

IPLV _{std} = 6.4			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT ^a	Required IPLV/NPLV					
46	75	29	7.15	7.47	7.72	8.10	8.37	8.58
45	75	30	7.05	7.35	7.58	7.93	8.18	8.36
44	75	31	6.95	7.23	7.45	7.77	8.00	8.16
43	75	32	6.85	7.13	7.33	7.63	7.83	7.98
42	75	33	6.75	7.03	7.22	7.49	7.68	7.82
41	75	34	6.65	6.93	7.12	7.37	7.55	7.67
46	80	34	6.65	6.93	7.12	7.37	7.55	7.67
40	75	35	6.55	6.83	7.01	7.26	7.42	7.54
45	80	35	6.55	6.83	7.01	7.26	7.42	7.54
44	80	36	6.44	6.73	6.92	7.15	7.30	7.41
43	80	37	6.32	6.63	6.82	7.05	7.19	7.30
42	80	38	6.20	6.53	6.72	6.95	7.09	7.19
41	80	39	6.06	6.42	6.62	6.85	6.99	7.08
46	85	39	6.06	6.42	6.62	6.85	6.99	7.08
40	80	40	5.91	6.30	6.52	6.76	6.89	6.98
45	85	40	5.91	6.30	6.52	6.76	6.89	6.98
44	85	41	5.75	6.17	6.40^c	6.66	6.79	6.89
43	85	42	5.57	6.03	6.28	6.55	6.70	6.79
42	85	43	5.37	5.88	6.16	6.44	6.59	6.69
41	85	44	5.15	5.71	6.01	6.33	6.49	6.59
40	85	45	4.91	5.53	5.86	6.20	6.37	6.48
Cond DT ^b			14.04	11.23	9.36	7.02	5.62	4.68

^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

^c All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$